AH760

Programmable crankshaft sensor

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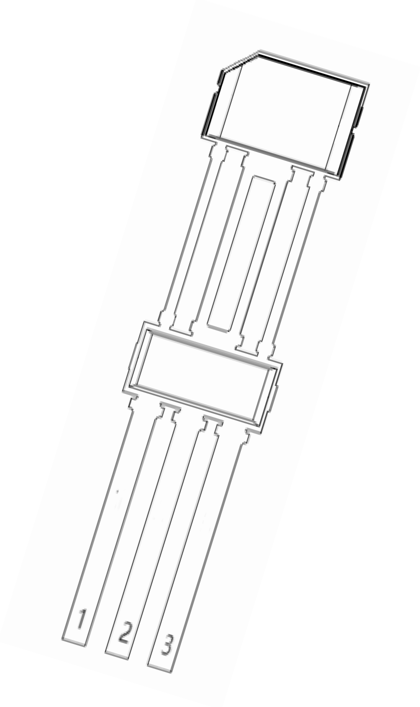
1. Product Introduction

AH760 is an active Hall sensor suitable for crankshaft applications and similar industrial applications, such as speed sensors or any speed sensor with high precision and low jitter capability. The working temperature range is -40 ℃ to 150 ℃. Package PG-SSO-3-52/TO94-3, compliant with AEC-Q100 certification requirements.



2. Product Features

- Measure the speed and position of gears
- Set switching points in the middle of the tooth structure to achieve backward compatibility
- Based on differential principle design, it has good anti-interference or noise performance
- Digital signal output, programmable output protocol including diagnostic interface
- Direction detection and start stop algorithm
- High precision, low jitter
- High sensitivity and large air gap
- The end of the production line can be programmed to adapt to engine parameters
- Can be used as a differential camshaft sensor
- Wide working temperature range

3. Application

- Speedometer
- Crankshaft sensor
- High precision low jitter speed sensor

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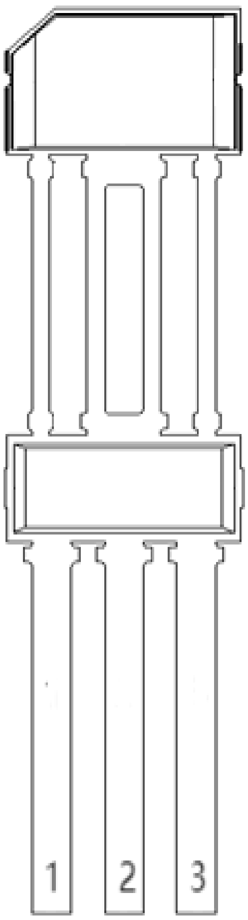
4. Product packaging

Part No.	operation temperature	Packages	Packing
AH760UR	-40℃～150℃	TO94-3L	1000PCS/bag
AH760PG	-40℃～150℃	PG-SSO-3-52	1000PCS/bag

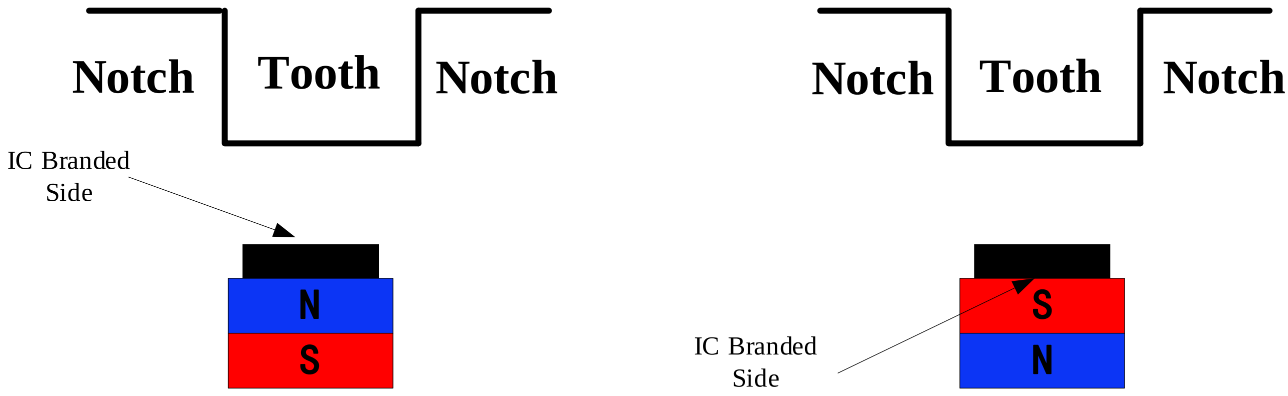
5. Pin information



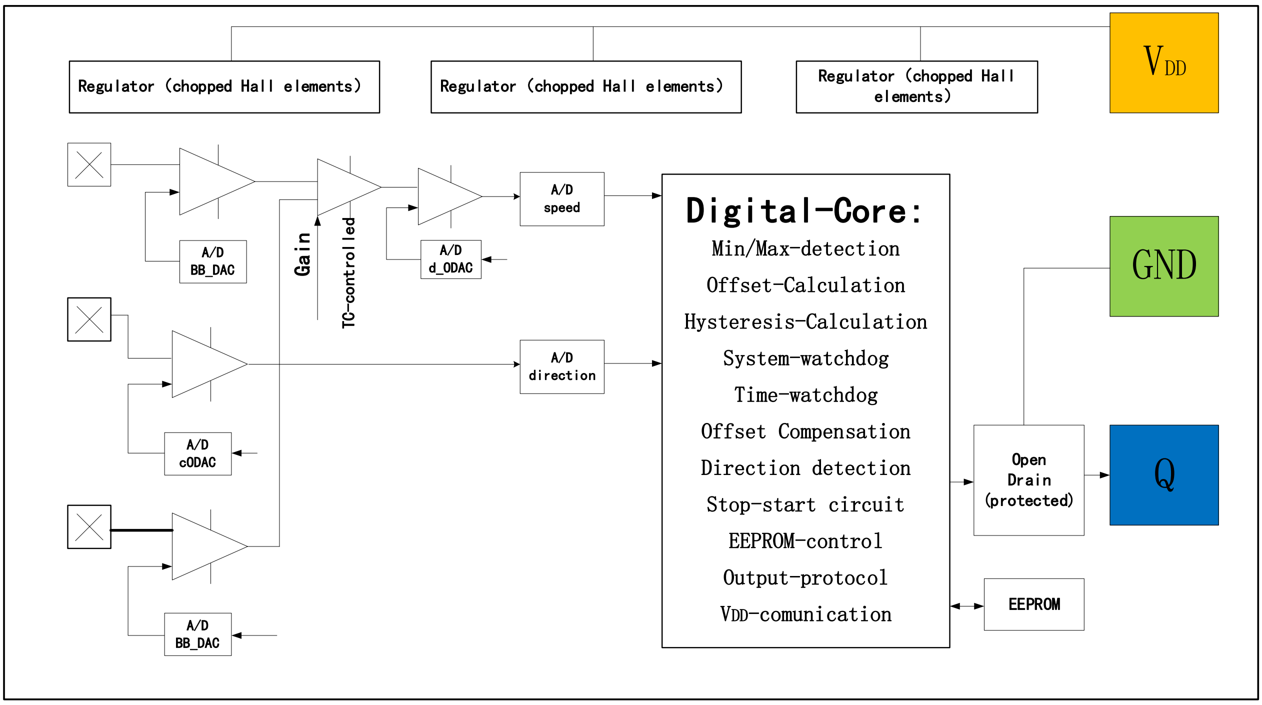
No.	Pin Name	Type	Functions
1	V_{DD}	SUPPLY	Power/programming pins
2	GND	GND	Grounding/programming pins
3	Q	OD	OPEN DRAIN

6. Functional Block Diagram

6.1 Definition of magnetic field direction



6.2 Functional Block Diagram



6.3 Basic Operation

The basic operation of the AH760 is to transpose the magnetic field produced by a spinning target wheel into speed pulses with directional information at the output pin. The pulse width indicates forward or backward direction information and can be adjusted in EEPROM-options. It is also possible to parameterize output switching without direction information like it is requested for differential CAMshaft sensors. The correspondence between field polarity and output polarity can be set according to the application needs as well. By definition a magnetic field is considered as positive if the magnetic North Pole is placed at the rear side of the sensor.

For understanding the operation five different phases have to be considered:

• Power-on phase

– starts after supply release

– lasts tpower-on (power-on time)

– IC loads configuration and settings from EEPROM and initializes state machines and signal path

– output is locked HIGH

• Initial phase (uncalibrated mode)

– starts after Power-on phase

– lasts one clock cycle

– IC enables output switching, extrema detection and threshold adaption

• Calibration phase 1 (calibrated mode)

– starts after Initial phase

– lasts until the sensor has observed 3 mangetic edges (maximum 4 magnetic edges) and is able to perform the most likely final threshold update needed for transition to “Calibration Phase 2”.

– IC performs fast adaptation of the threshold according to the application magnetic field

– initial and second switching (uncalibrated mode)of the output is performed according to the detected field change of the differential magnetic field.

– length of the output-pulse is derived from the center Hall probe (direction signal) sampled at the zero crossing of the differential outer Hall probes (speed signal)

– length of the very first pulse is “forward-pulse” according to choosen protocol in EEPROM (direction information is not valid at this time)

• Calibration phase 2

– starts after “Calibration Phase 1”

– lasts until the sensor has reached final offset-calibration which is minimum 5 teeth / maximum 64 teeth (pole-pairs) according to choosen algorithm in EEPROM

– IC performs slow and accurate adaptation of the threshold according to the application magnetic field

– output switching (calibrated mode) is performed according to magnetic zero-crossing of the differential magnetic field

– length of the output-pulse is derived from the center Hall probe (direction signal) sampled at the zero crossing of the differential outer Hall probes (speed signal)

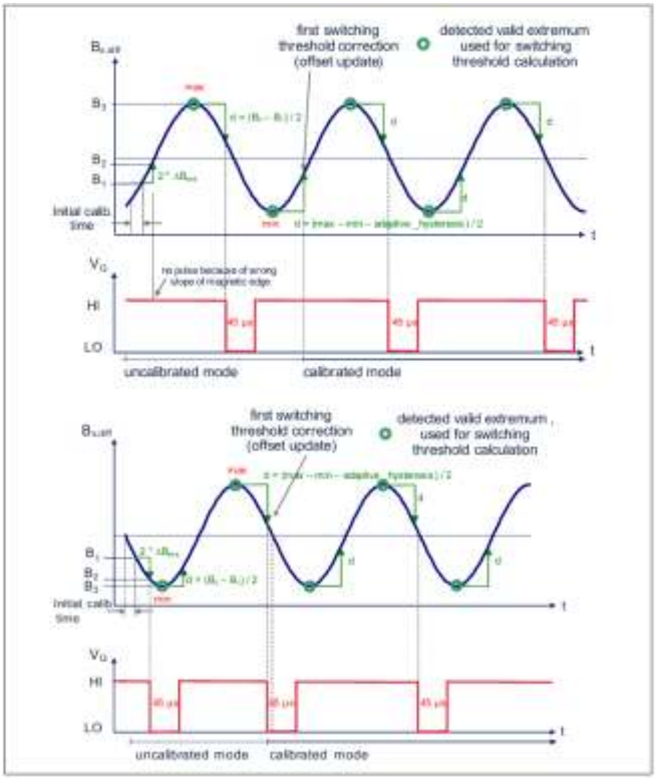
• Running phase

– starts after “Calibration Phase 2”

– lasts indefinitely if no special condition is triggered

– performs a filter algorithm in order to maintain superior phase accuracy and improved jitter

– output switches according to the threshold value, according to the hidden hysteresis algorithm and according to the choosen output-protocol



6.3.1 Power-on Phase

The operation in Power-on Phase is to refresh the trimming coefficients and algorithm settings from the EEPROM and to allow the signal path to stabilize. If an unrecoverable error is found at EEPROM refresh, the output will remain locked HIGH during the entire operation.

6.3.2 Initial Phase

The magnetic field is measured by three chopped Hall probes. From the outer Hall probes located at a distance of 2.5mm a differential magnetic field is measured which is named “speed” in this datasheet. From the center Hall probe the “direction” signal is derived. Both signals are converted to a digital value via an ADC.

6.3.3 Calibration Phase

The adaptation of the threshold to the magnetic field is performed in Calibration Phase. This adaptation is done based on the field values set by teeth and notches (or based on poles on the pole wheel). These variations in the magnetic field are followed by a local extrema detection state machine in the IC. During Calibration Phase the IC permanently monitors the magnetic signal. First and second switching is performed when the speed-path recognized a certain change of magnetic field and the polarity meets the switching criterion derived from the EEPROM. The third and further pulse of the output is performed at “zero-crossing” of the speed path. “Zero crossing” is the 50%-value between detected minimum and detected maximum - also known as “offset”.

6.3.4 Running Phase

According to the choosen algorithm in EEPROM an avaerage of 5 to 58 pulses is used to do an offset-calculation and an offset-update.

The following rules have to be verified before applying a computed update to the threshold register:

• Compatibility between threshold update sign and magnetic edge

• Threshold update has to be large enough not to be discarded (minimum_update)

• Threshold update is limited to a maximum value based on field amplitude and on comparison with absolute field value (maximum_update)

• Computed threshold update is always halved before being applied

• Threshold update is filtered to discourage consecutive updates in opposite direction (consecutive_upd_req) Typically the offset is updated after one complete revolution of the target wheel, which is effectively 58 teeth.

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Offset update algorithm	58 teeth	-	58	-	-	one revolution of a 60-2 target
	32 teeth	-	32	-	-	one revolution of a 32-teeth /pole-pair target
	5 times the same sign for offset-update	5	-	-	-	suggested for wheels with different number of teeth or for large run-out.

Table 6-1: Available offset update algorithm to be choosen in EEPROM

6.3.5 Averaging Algorithm

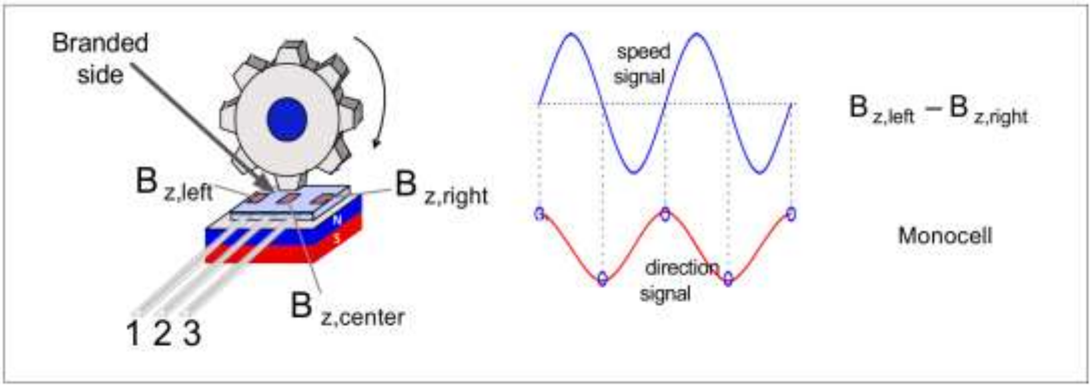
To calculate the threshold within the running phase, valid maxima and minima are averaged to reduce possible offset-updates. Each offset-update gives an increased jitter, which has to be avoided.

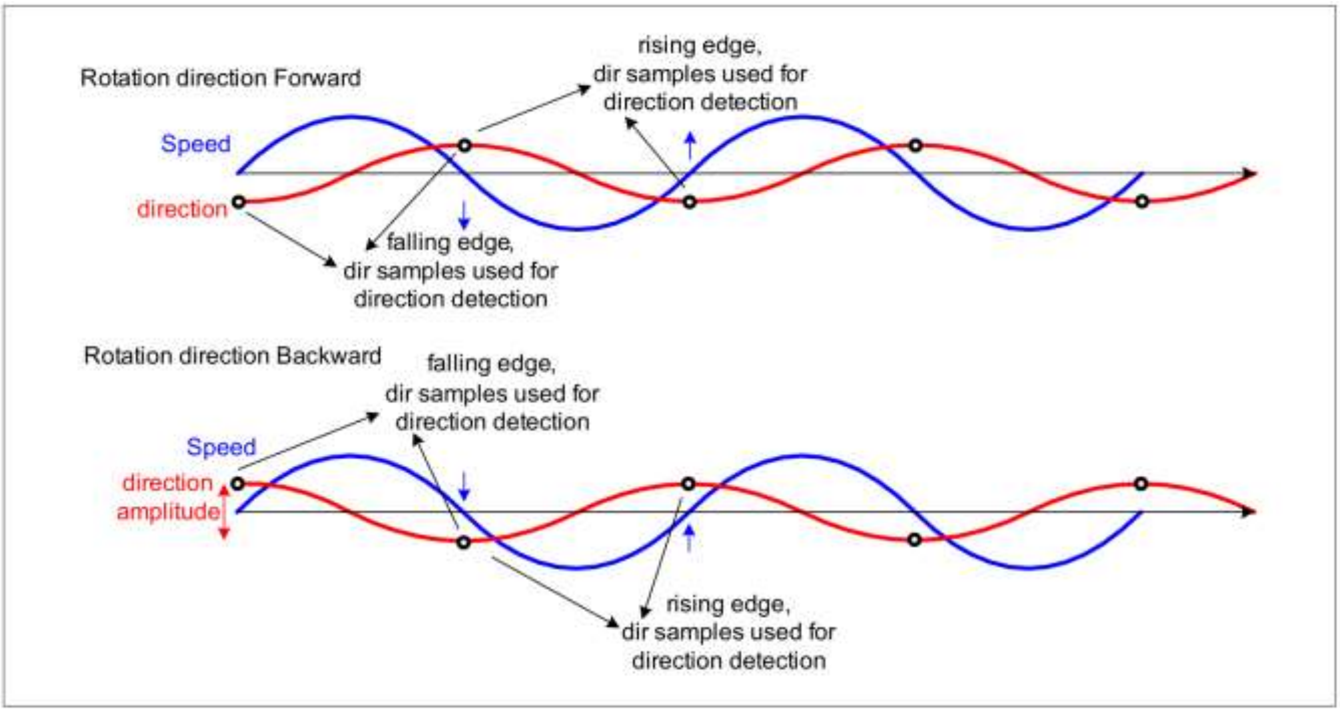
6.3.6 Direction Detection

Direction is calculated from the amplitude-value of direction-signal sampled at zero-crossing of speed channel. For each pole-pair or pair of tooth and notch two digital values are generated for detecting the direction. Subtracting the second value from the first value the direction is determined by its sign. According to EEPROM-setting a positive sign is either direction forward or direction back.

EEPROM EDGE_POLAR	EEPROM FORWARD_DE F	Function
0	0	Forward-pulse is issued when wheel rotates from pin 1 to pin 3. Falling edge of output-pulse occurs at middle of the notch.
0	1	Forward-pulse is issued when wheel rotates from pin 3 to pin 1. Falling edge of output-pulse occurs at middle of the tooth.
1	0	Forward-pulse is issued when wheel rotates from pin 1 to pin 3. Falling edge of output-pulse occurs at middle of the tooth.
1	1	Forward-pulse is issued when wheel rotates from pin 3 to pin 1. Falling edge of output-pulse occurs at middle of the notch.

Table 6-2 EEPROM-options for polarity and direction



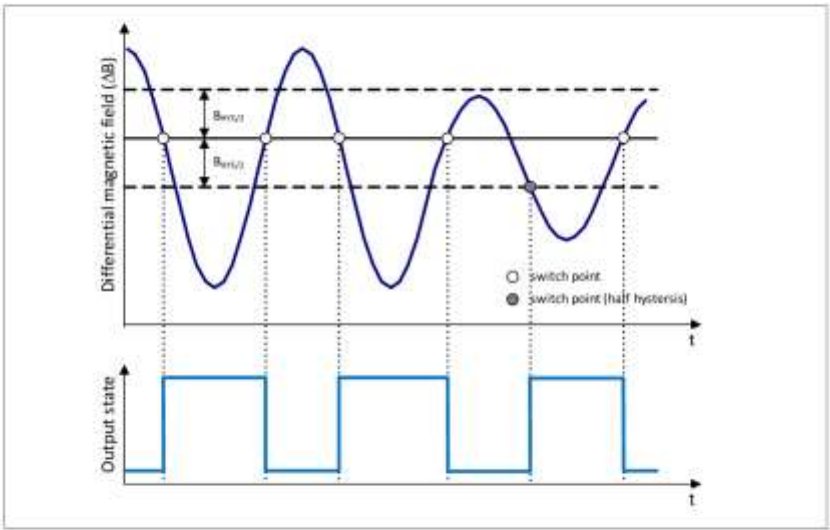


6.3.7 Direction Detection Threshold

To recognize a change in rotational direction of the target wheel a is used. The peak-to peak signal of direction is averaged over the last 5 teeth and is used as 100% value. Whenever a new minimum or a new maximum is measured, a threshold of 25% is calculated.

When the direction remains unchanged, the expected signal amplitude at the next sampling point is another 100%. If the direction of rotation changes, the expected signal amplitude will remain the same as before. To distinguish between these two situations, a virtual threshold of 25% was considered. Through EEPROM, this 25% can be programmed to 12.5% (direction change standard).

6.4 Hysteresis Concept

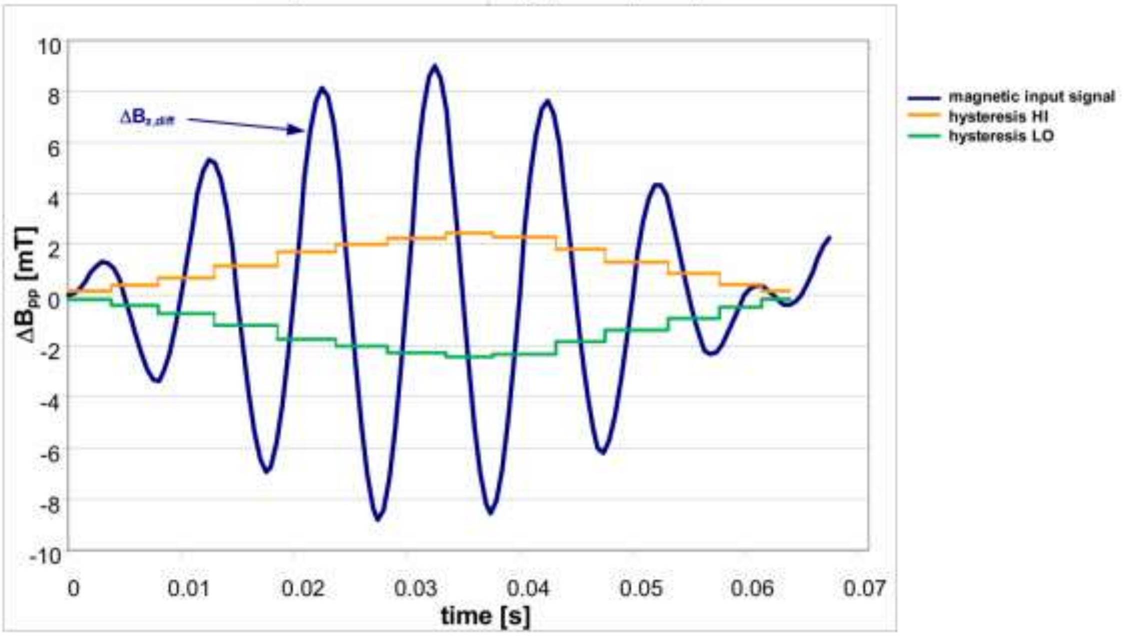


The prefered switching behavior for crankshaft application in terms of hysteresis is called hidden adaptive hysteresis. For reason of long notches or long teeth there is the EEPROM possibility to go for visible hysteresis as well. Another EEPROM possibility is fixed hysteresis, which allows robustness against metallic flakes attached by the back-bias-magnet.

Hidden adaptive hysteresis means, the output always switches at the same level, centered between upper and lower hysteresis. These hysteresis thresholds needs to be exceeded and are used to enable the output for the next following switching event. For example, if the differential magnetic field crosses the lower hysteresis level, then the output is able to switch at the zero crossing. Next following upper hysteresis needs to be exceeded again in order to enable for the next switching. Furthermore, the function of half hysteresis maintains switching whenever the upper hysteresis level is not exceeded, but the lower hysteresis level is crossed again, then the output is allowed to switch, so that no edge is lost. However, this causes additional phase error.

Doing an adaptive hysteresis gives advantage at small airgap (large signal) to have big hysteresis. Compared with fixed hysteresis a small vibration cannot cause additional switching. The adaptive hysteresis calculation is 25% of the peak to peak value of the differential velocity signal. The minimum hysteresis is derived from EEPROM-setting“HYST MIN”.

Hysteresis = 0.25 * ΔB_{pp} (peak to peak)

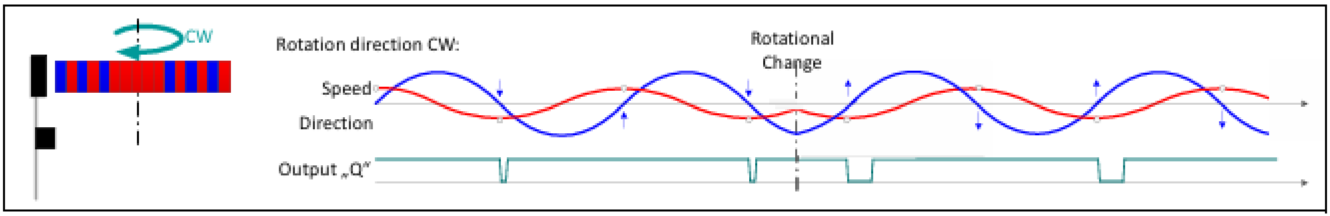


6.5 Rotational Direction Definition and Edge Polarity Definition

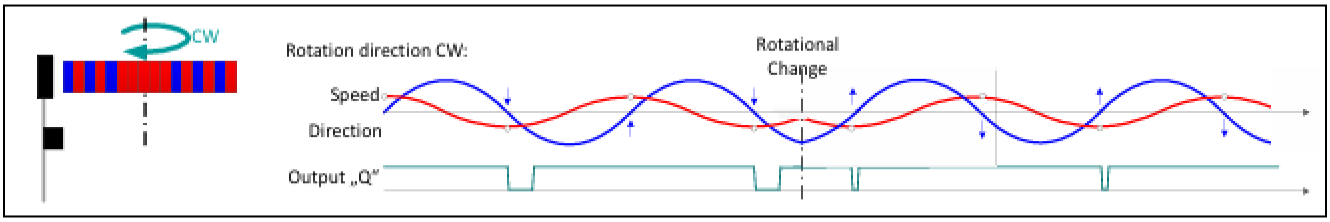
AH760 has EEPROM-options to change the position of the output-protocol. In the application the switching point is either the middle of the tooth or the middle of the notch (magnetic encoder wheel: middle of north pole or middle of south pole). From magnetic point of view it is zero crossing of the differential speed signal: Either rising edge or falling edge. The EEPROM-Bit “EDGE_POLAR” parametrizes the sensor to one of the edges.

In addition there is an option to issue “forward”-pulses either in CW rotational direction or CCW rotational direction: “FORWARD_DEF”.

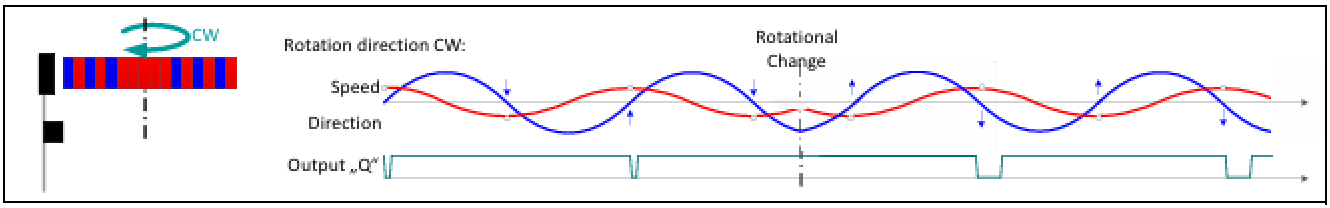
Both EEPROM-bits are independent from each other. Figure11 Signal output in setting “EDGE_POLAR



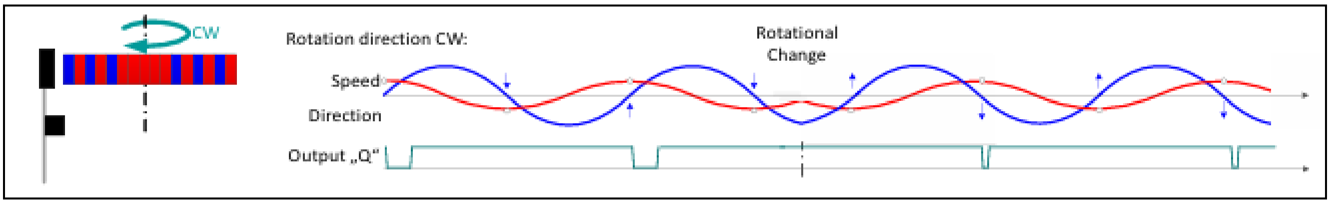
Signal output in setting “EDGE_POLAR = 0” and “FORWARD_DEF” = 0



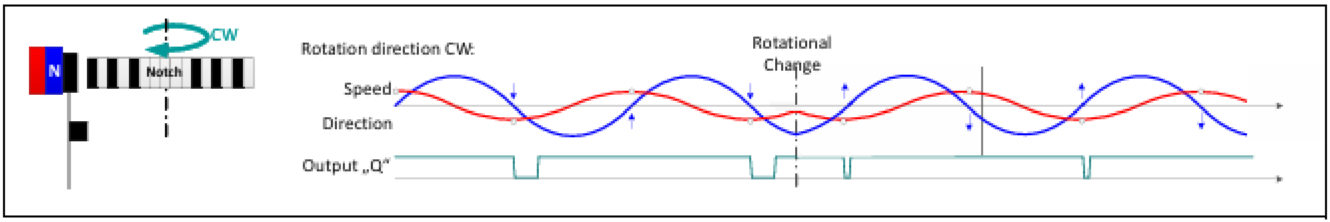
Signal output in setting “EDGE_POLAR = 1” and “FORWARD_DEF” = 1



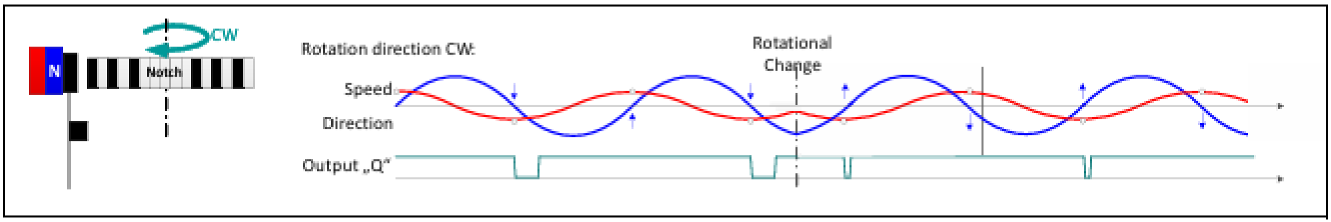
Signal output in setting “EDGE_POLAR = 1” and “FORWARD_DEF” = 0



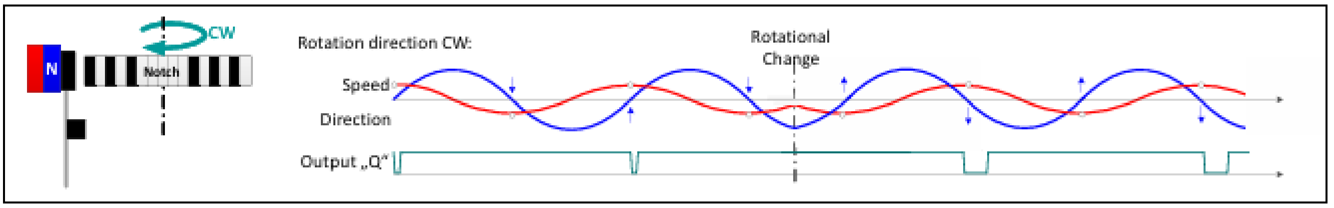
Signal output in setting “EDGE_POLAR = 0” and “FORWARD_DEF” = 1



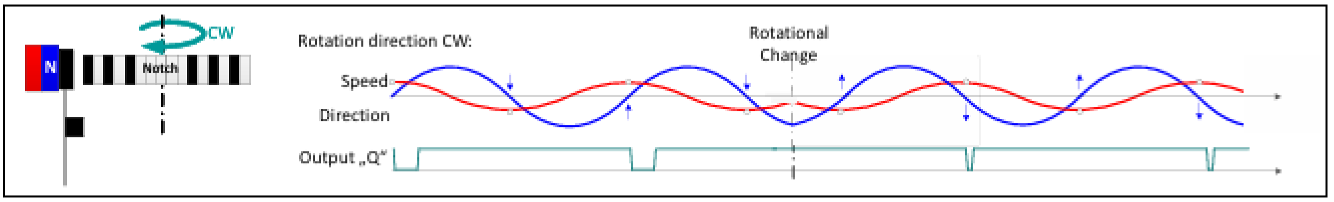
Signal output in setting “EDGE_POLAR = 0” and “FORWARD_DEF” = 0



Signal output in setting “EDGE_POLAR = 1” and “FORWARD_DEF” = 1



Signal output in setting “EDGE_POLAR = 1” and “FORWARD_DEF” = 0



Signal output in setting “EDGE_POLAR = 0” and “FORWARD_DEF” = 1

The AH760 is preprogrammed and has locked EEPROM. In Figure 18 the behavior is pictured when following conditions are met:

• Backbias magnet is attached with magnetic north pole to the back of AH760. (pictured in left part of Figure 3.

• Forward-pulses (crank forward pulse-length = 45µsec) are issued when toothed wheel moves from package-pin 3 (“Q”) to packape-pin 1 (“VDD”).

• Backard-pulses (crank reverse pulse-length = 90µsec) are issued when toothed wheel moves from package-pin 1(“VDD”) to packape-pin 3 (“Q”).

• The pulse is issued in the middle of the tooth of the toothed wheel.

6.6 System Watchdog

The system watchdog is monitoring following parts in the digital core and at the output:

• Finding valid maxim in the speed signal

• Finding valid minim in the speed signal

• Finding valid zero-crossing of the speed signal

• Monitoring the output switching

As long the speed signal and the corresponding output switching is fine the system watchdog will reset itself automatically at every output-switching. As soon the system watchdog detects valid maximum, valid minimum and valid zero-crossing without a switching event at the output, the system watchdog will increase its counter. Switching of the output sets the counter to zero. When the counter reaches its limit the offset will be reset.

The advantage of this system watchdog is to avoid “flat line” behavior at the output. Once there happened a massive event in the sensing system (i.e. hit on the tooth, sudden air gap jump, ...), the AH760 is able to recover itself. The system watchdog can be enabled by EEPROM setting “WATCH_DOG_EN”.

6.7 Stop Start Watchdog

The Stop Start watchdog allows AH760 to stay calibrated as much as possible during stand-still of the target wheel and a possible temperature-drift of 60K. It can be enabled by EEPROM-option. Basically the Stop Start watchdog is a time-out of 1.4 seconds. After 1.4 seconds time out between two zero crossing of the speed channel (crankshaft wheel stopped) the Stop Start Watchdog will enter active state. No output switching is enabled during active watchdog state. After a signal-change in speed channel above DNC within 1.4 seconds (crankshaft wheel rotates) the AH760 will use known signal-amplitude and perform output-switching with the new switching threshold at the new temperature. At standstill of the target wheel the stop start watchdog will enable AH760 to not issue any wrong pulse at the output:

- No additional pulses
- No missing pulses
- No false rotational direction information

Combining the System Watchdog and the Stop Start Watchdog an immunity to vibration can be added to the Stop-Start-behavior. Further details are available on request.

6.8 High Speed Mode

The high speed mode can be switched on or off by EEPROM bit “HIGH_SPEED”. Switched to state “off” the AH760 behaves as described. Switched to state “on” the AH760 stops direction detection above a certain input signal frequency of typicaly 1.8kHz and continues with the last detected direction. To switch to high speed mode the frequency has to be measured two times. Comming from high frequencies the direction detection is enabled again going below the frequency threshold of 1.5kHz. In mode TSS = 1 the limits are 4.3kHz and 4.0kHz. All values are typical values.

6.9 Serial Interface

The serial interface is used to set parameter and to program the sensor IC, it allows writing and reading of internal registers. Data transmission to the IC is done by supply voltage modulation, by providing the clock timing and data information via only one line. Data from the IC are delivered via the output line, triggered by as well clocking the supply line. In normal application operation the interface is not active, for entering that mode a certain command right after power-on is required. A detailed interface document is available on request, containing description of electrical timing and voltage requirements, as well as information about data protocol, available registers and addresses.

7. EEPROM Description

Several options of TLE4929C can be programmed via an EEPROM to optimize the sensor algorithm to the individual target wheel and application requirements. The EEPROM memory is organized in 2 customer lines, whereas each line is composed of 16 data bits and additional 6 bits for error detection and correction, based on ECC (Error Correction Code). For more detailed information about EEPROM access and programming an EEPROM Programming manual is available.

Type	Description	TC (typical)	fits magnetic material
AH760-X	EEPROM preprogrammed and locked	-825 ppm	SmCo, NdFeB
AH760-F	EEPROM unlocked	-1400 ppm	NdFeB, Fe

Table7-1: Temperature-Compensation for used magnetic material

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Customer line #1															

Table7-2: EEPROM Address 0x0

Field	Bit	Type	Description	AH760 -X	AH760 -F
not used	15	r	always read as “0”	0	0
STOP_ENABLE	14	rw	0 = Disable stop mode 1 = Enable stop mode	1	1
HIGH_SPEED	13	rw	0 = Enabled motion detection 1 = Same pulse and phase as before when above 1.5kHz	1	1
DIR_CHANGE	12	rw	0=1/4 Criteria for direction change 1=1/8 Criteria for direction change	0	0

WATCH_DOG_EN	11	rw	0 = Watchdog off 1 = Watchdog on	0	0
not used	10..2	rw	to be set to "000000000"	000000000	000000000
PULSE_WIDTH	1	rw	0 = Default pulse length for all pulses 1 = All pulses shortened by 4µs (GM-pullup)	0	0
POLE_WHEEL	0	rw	0 = Back bias self calibration on startup – back bias applications 1 = Back bias in center and differential path set to ~0mT	0	1

Table7-3: Functional Description Address 0x0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Customer line #2															

Table7-4: EEPROM Address 0x1

Field	Bit	Type	Description	AH760 -X	AH760 -F
not used	15:14	rw	to be set to "00"	00	00
PW_CHOICE	13	rw	Choice of pulse length at direction detection forwards/backwards time, pulse length is 3µs shorter by default and can be shortened by additional 4µs with the PULSE_WIDTH bit. 0 = 45 / 90µs 1 = 45 / 135µs	0	0
not used	12	rw	to be set to "0"	0	0
FORWARD_DEF	11	rw	0 = none inversion of forward definition 1 = inversion of forward definition	1	0
EDGE_POLAR	10	rw	0 = non-inverted 1 = inverted	0	1
HYST_ADAPT	9	rw	0 = 25% 1 = 31.25%	0	0
HYST	8	rw	0=0.75mTpkpk 1=1.5mTpkpk	1	1
HYST_TYPE	7	rw	0 = Hidden adaptive hysteresis 1 = Visible adaptive hysteresis	0	0
DNC_MIN	6:5	rw	Minimal DNC (Digital Noise Constant): 00=0.75mTpkpk 01=1.5mTpkpk	01	01

			10=2.5mTpkpk 11=5mTpkpk		
DNC_ADAPT	4	rw	Following value is used for uncalibrated mode: 0=25% 1=31.5%	0	0
CRANK_TEETH	3	rw	0=58teeth 1=32teeth	0	0
DIR_ENABLE	2	rw	0 = Direction detection off 1 = Direction detection on	1	1
ADAPT_FILT	1	rw	0=Slow adaptation tracking: average over 32/58 (CRANK_TEETH) edges…) 1=Fast adaptation tracking: Each valid min/max is considered and allows a small offset-update. When the last 5 updates have the same sign a full offset-update will be performed.	0	0
LOCK	0	rw	0=User area of EEPROM is unlocked 1=User area of EEPROM is locked (no reprogramming possible)	1	0

Table7-5: Functional Description Address 0x1

8. Electromagnetic characteristics

8.1 electromagnetic parameters

8.1.1 absolute maximum rating

Parameter	Symbol	Values			Unit	TestCondition
		Min.	Typ.	Max.		
Voltages						
Supply voltage without supply resistor	V_{DD}	-16	–	18	V	continuous, $T_J \leq 175°C$
		–	–	27	V	max. 60s, $T_J \leq 175°C$
		-18	–	–	V	max. 60s, $T_J \leq 175°C$
Output OFF voltage	V_{Q_OFF}	-1.0	–	–	V	max. 1h, $T_{Amb} \leq 40°C$
		-0.3	–	26.5	V	continuous， $T_j \leq 175°C$

Output ON voltage	V_{Q_ON}	–	–	16	V	continuous， T_{Amb}≤40°C
		–	–	18	V	max. 1h, T_{Amb} ≤40°C max. 1h, T_{Amb} ≤40°C
		–	–	26.5	V	max. 60s, T_{Amb}≤40°C
Temperatures						
Junction temperature range	T_J	-40	–	185	°C	Exposure time: max. 10×1h, V_{DD}=16V
Induction						
Magnetic field induction	B_Z 1)	-5	–	5	T	Magnetic pulse during magnet magnetization. Valid 10s with Tambient ≤80°C
ESD Resistivity						
ESD	ESD_{HBM}	-6	–	6	kV	HBM 2)

1) Guaranteed by design

2) ESD susceptibility, HBM according to EIA/JESD 22-A114B

Note: Stresses above the max values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.

8.1.2 Operating Range

All parameters specified in the following sections refer to these operating conditions unless otherwise specified.

Parameter	Symbol	Values			Unit	Test Condition
		Min.	Typ.	Max.		
Voltages						
Supply voltage without supply resistance R_S	V_{DD}	4.0	–	16	V	
Continuous Output Off voltage	V_{Q_OFF}	-	–	16	V	
Supply voltage power-up/down voltage ramp	dV_{DD}/dt	3.0	–	1e4	V/ms	

Currents						
Supply current	I_{DD}	8.0	_	13.4	mA	
Continuous output On current	I_{Q_ON}		_	15	mA	$V_{Q\_LOW} < 0.5$ V
Capacitance						
Capacitance between IC supply & ground pins	C_{VDD}	198	220	242	nF	
Output capacitance between IC output and ground pins	C_Q	1.62	1.8	1.98	nF	
Direction Detection						
Frequency range for direction detection	f_{Dir}	0	_	1800	Hz	For increasing rotational frequency
		0	_	1500	Hz	For decreasing rotational frequency
Programming						
Maximum No. of EEPROM programming cycles	N_{PROG}	_	_	100	n	
Magnetic Signal						
Magnetic signal frequency range	f	0	_	8000	Hz	Full accuracy
		8000	_	10000	Hz	10% degraded jitter
Dynamic range of the magnetic field of the differential speed channel	$Dr_{mag\_field\_s}$	-120	-	120	mT	ADC-range
Dynamic range of the magnetic field of the direction channel	$DR_{mag\_field\_dir}$	-60	-	60	mT	ADC-range
Static range of the magnetic field of the outer Hall probes in back-bias configuration	$SR_{mag\_field\_sbb}$	0	-	550	mT	No wheel in front of module / Offset-DAC Compensation-range
Static range of the magnetic field of the outer Hall probes in magnetic encoder wheel configuration	$SR_{mag\_field\_spw}$	-10	-	10	mT	Static absolute offset for pole wheel / Offset-DAC Compensation-range / independent from Bit "POLE_WHEEL"

Static range of the magnetic field of the center Hall probe	$SR_{mag\_field\_dir}$	-100	-	450	mT	No wheel in front of module/ Center-Offset DAC-Compensation range
Allowed static difference between outer probes	$SR_{mag\_field\_diff}$	-30	-	30	mT	No wheel in front of module
Magnetic differential field amplitude for full performance on stop-start	$\Delta B_{Speed\text{-}Stop\text{-}Start}$	9	-	-	mTpk pk	No false pulses for temperature drift of ≤ 60 K during stop-start state. Tolerated change of speed-channel mean value ≤ 3mT
		6	-	-	mTpk pk	No false pulses for temperature drift of ≤ 40 K during stop-start state. Tolerated change of speed-channel mean value ≤ 2m
		4	-	-	mTpk pk	No false pulses for temperature drift of ≤ 20 K during stop-start state. Tolerated change of speed-channel mean value ≤ 1.5mT
Temperatures						
Normal operating junction temperature	T_J	-40	–	175	°C	Exposure time: max. 2500h at T_J=175°C, V_{DD}=16V
		-	-	185	°C	Exposure time: max. 10×1h at T_J=185°C, V_{DD}=16V, additive to other lifetime
Not operational lifetime	T_{no}	-40		150	°C	Without sensor function. Exposure time max 500h@ 150°C; increased time for lower temperatures according to Arrhenius-Model, additive to other lifetime
Ambient temperature range for customer programming	T_{RDPROG}	15	25	130	°C	
Temperature variations between engine stop and restart	$\Delta T_{Stop,start}$	–	–	60	°C	Device powered continuou s-sly
Temperature compensation range of magnetic material	TC	-1400	–	0	ppm	Internal compensation of magnetic signal amplitude of speed signal

8.2 Electrical and Magnetic Characteristics

All values specified at constant amplitude and offset of input signal, over operating range, unless otherwise specified. Typical values correspond to VS = 5V and TAmb. = 25°C

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Condition
Voltages						
V_{Qsat}	Output saturation voltage	-	-	500	mV	$I_Q \leq 15mA$
V_{DD_clamp}	Clamping voltage VDD-Pin	42	-	-	V	leakage current through ESD diode < 0.5mA
V_{Qclamp}	Clamping voltage VQ-Pin	42	-	-	V	leakage current through ESD diode < 0.5mA
V_{DD_reset}	Reset voltage	-	-	3.6	V	
Current						
I_{Qleak}	Output leakage current	-	0.1	10	µA	V_Q =18 V
I_{Qshort}	Output current limit during short-circuit condition	30	-	80	mA	
Temperature						
T_{prot}	Junction temperature limit for output protection	190	-	205	℃	
Time and Frequency						
t_{power_on}	Power on time	0.8	0.9	1	ms	During this time the output is locked to high.
t_{delay}	Delay time between magnetic signal switching point and corresponding output signal falling edge switching event	10	14	19	µs	Falling edge
t_{fall}	Output fall time	2.0	2.5	3.0	µs	VPullup = 5 V, RPullup=1.2kΩ (+/ 10%), CQ=1.8nF (+/-15%), valid between 80% - 20%
		3.2	4.5	5.8	µs	VPullup = 5 V, RPullup=1.2kΩ (+/ 10%), CQ=1.8nF (+/-15%), valid between 90% - 10%

t_{rise} 1)	Output rise time	4	-	11.4	µs	RPullup=1.2kΩ (+/-10%), CQ=1.8nF (+/-15%), valid between 10% - 90%
Minimum Field Change during Start up to generate Output Switching						
DNC_{min}	Digital noise constant of speed channel during start up (change in differential field	0.53	0.75	0.97	mTpkpk	EEPROM “DNC_MIN”: Option 00 2)
		1.22	1.5	1.78	mTpkpk	EEPROM “DNC_MIN”: Option 01
		2.14	2.5	2.86	mTpkpk	EEPROM “DNC_MIN”: Option 10
		4.44	5	5.56	mTpkpk	EEPROM “DNC_MIN”: Option 11
Hysteresis Of Switching Threshold						
HYS_{min}	Minimum hysteresis threshold of speed channel	0.53	0.75	0.97	mTpkpk	EEPROM “HYST”: Option 02)
		1.22	1.5	1.78	mTpkpk	EEPROM “HYST”: Option 1
$HYS_{adaptiv}$ e	Adaptive hysteresis threshold of speed channel	–	25	–	%	EEPROM “HYST_ADAPT”: Option 0
		–	31.25	–	%	EEPROM “HYST_ADAPT”: Option 1
Switch Off set, Error	Switching level offset	-350	–	350	µT	For magnetic speed signal =10mTpkpk : resulting in phase error / duty cycle error.
Accuracy and Repeatability						
Jitter 3)	Repeatability (Jitter)	–	–	0.015	°Crank	3 sigma, ΔBpkpk = 20mTpkpk
		–	–	0.025	°Crank	3 sigma, ΔBpkpk = 9mTpkpk , measured on coil using sinus signal, Ta=150°C, f=8kHz
nStart 4)	Number of wrong pulses at start-up	–	–	0	n	Engine starts in continuous forward rotational direction
		0	–	1	n	Engine starts in continuous backward rotational direction
nStop,start 4)	Number of wrong pulses after stop-start	–	–	0	n	Multiple rotational direction changes >

						6°Crank allowed
Phirunning[3])	Maximum phase error	-0.2	–	0.2	°Crank	ΔBSpeed > 9mTpkpk ,signature excluded, accuracy on mentioned wheel
	Maximum phase error after stop-start	-1.7	–	3.2	°Crank	Reduced phase accuracy only for first pulse after stop-start-state / signature excluded
Run Out Capabilities						
Runoutglobal[4])	Global run out (speed and direction channel)	1. 0	–	1. 67	–	Ratio = Amplitude(max)pkpk / Amplitude(min)pkpk
		1. 0	–	2. 5	–	Ratio = Amplitude(max)pkpk / Amplitude(min)pkpk . Reduced performance in Stop-Start behavior.
Runouttooth,tooth[4])	Magnetic overshoot of signature region in speed signal. Magnetic overshot from tooth to tooth (polepair to polepair)	0. 8	1. 2	1. 6	–	Ratio = Amplitude(signature) / Amplitude(before/after). Valid for toothed target wheel.
		0. 7	1. 4	2. 5	–	Ratio = Amplitude(signature) / Amplitude(before/after). Valid for magnetic target wheel
Output Protocol Variants						
	Crankshaft without direction detection: Output follows profile of target wheel					Output "Q" changes state ("LOW" or "HIGH") in the middle of the tooth / middle of the notch
tfwd	Standard crankshaft protocol with direction	38	45	52	µs	VPullup = 5 V, RPullup=1.2kΩ (+/ 10%), CQ=1.8nF (+/- 15%), valid between 50% of falling edge to 50% of next rising edge
tbwd		76	90	104	µs	
tfwd	Optional crankshaft protocol with direction	38	45	52	µs	
tfwd		113	135	157	µs	

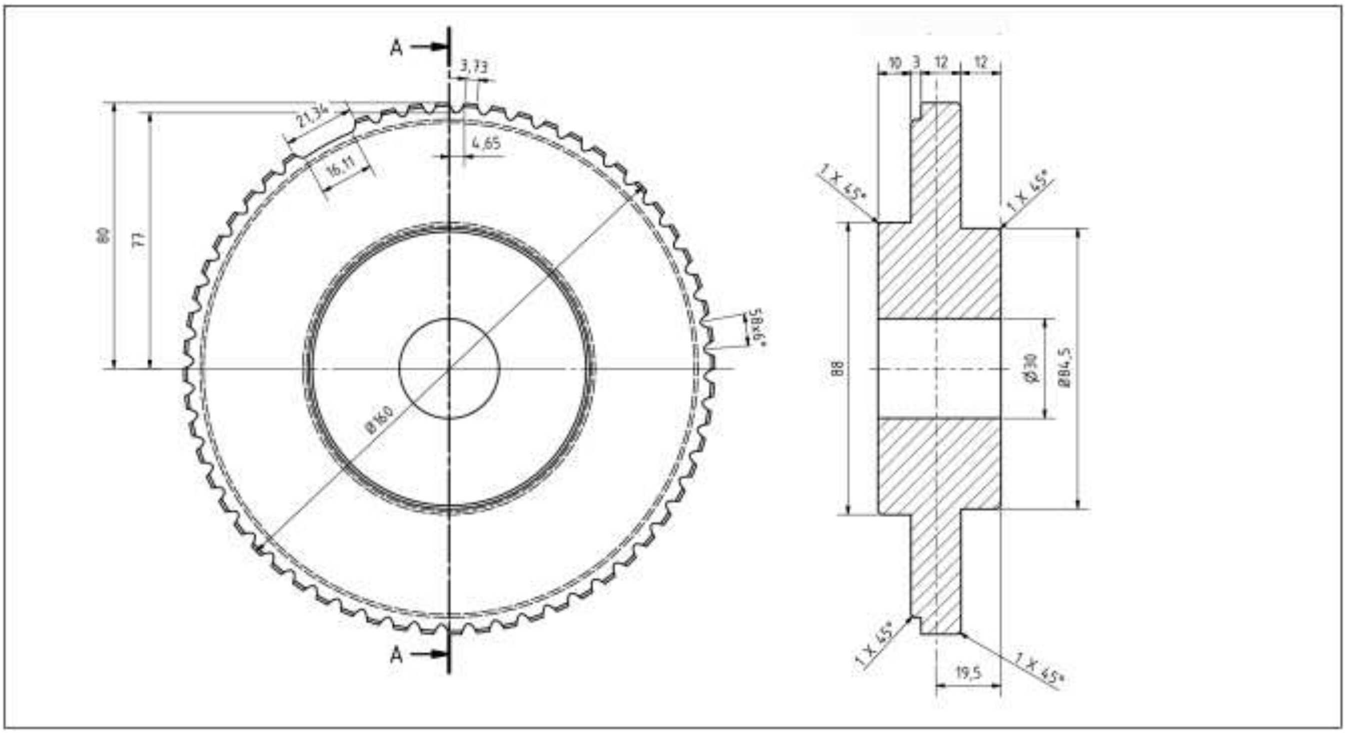
1) Application parameter, IC does not increase the rise time (max. value), Values are calculated and not tested

2) Smallest setting is not recommended for harsh environment: long tooth, long notch, vibration, run-

out of target wheel.

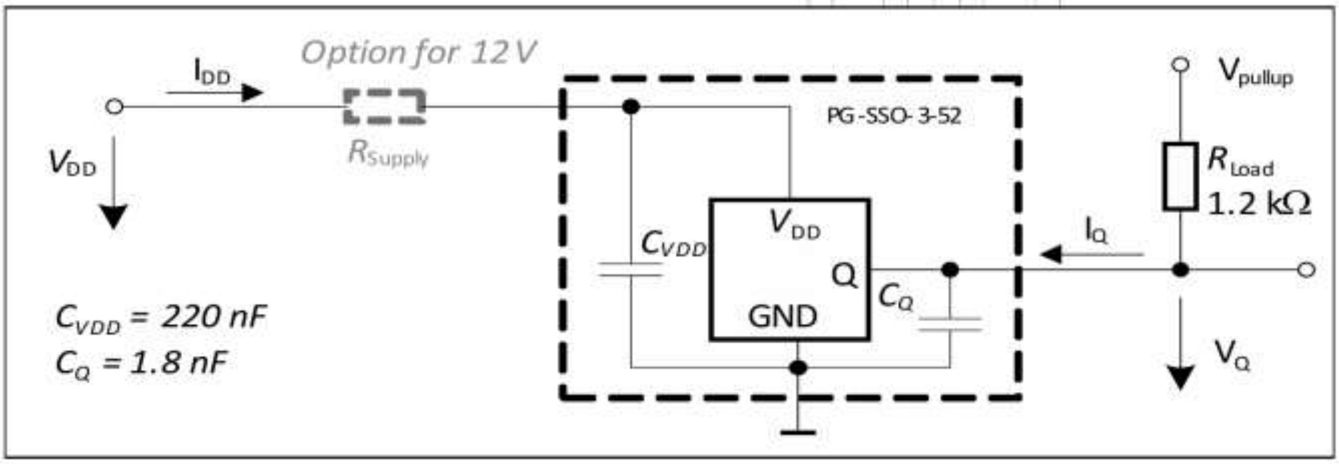
3) Parameter not subject to productive test. Verified by characterization in the laboratory based on jitter-measurement > 1000 falling edges. 4) Parameter not subject to productive test. Verified by laboratory characterization / design.

Note: The listed Electrical and magnetic characteristics are ensured over the operating range of the integrated circuit. Typical characteristics specify mean values expected over the production spread. If not other specified, typical characteristics apply at TAmb=25°C and VS=5V.

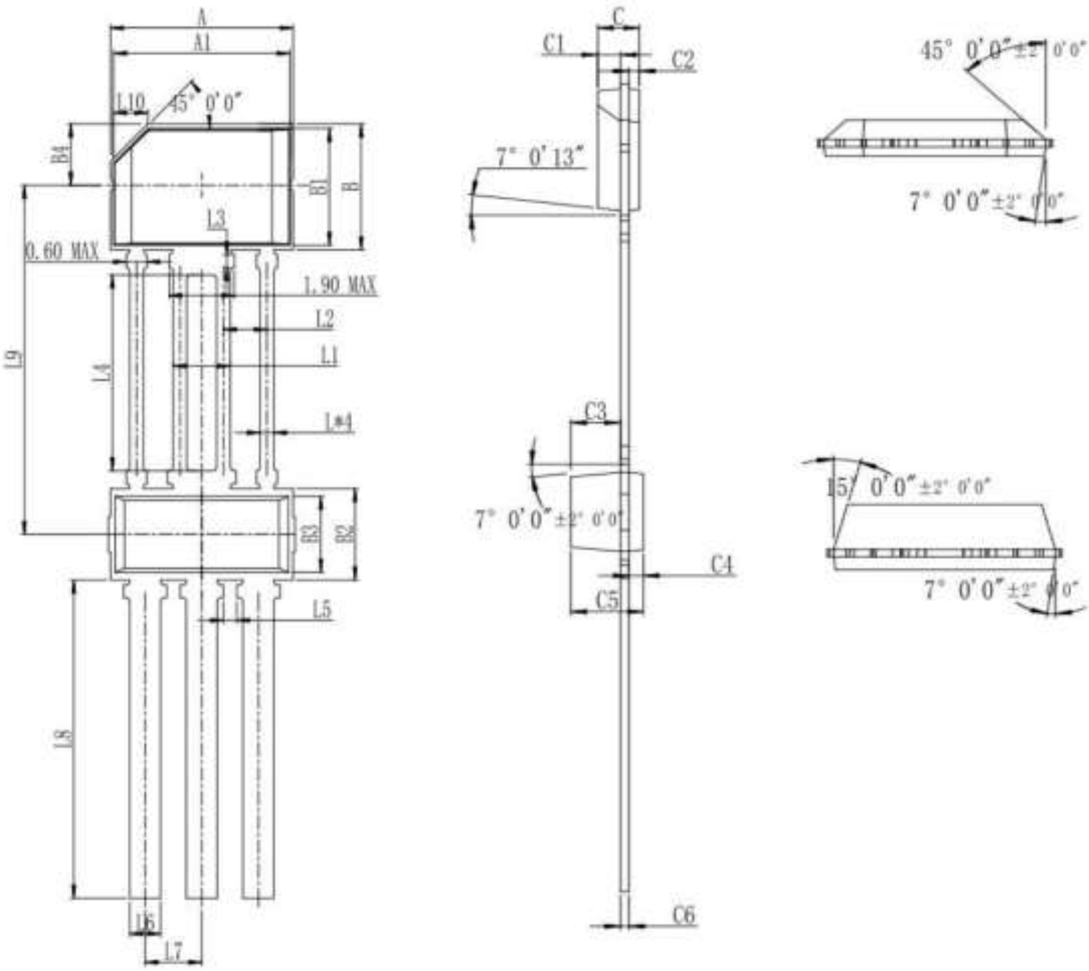


OEM-crankshaft wheel (outer diameter = 160mm)

9. Recommended application circuit



10. Package information



Symbol	Dimensions in Millimeters		
	Min	Typ	Max
A	5.24	5.34	5.44
A1	5.05	5.15	5.25
B	3.52	3.64	3.76
B1	3.28	3.38	3.48
B2	2.40	2.65	2.90
B3	2.10	2.20	2.30
B4	1.68	1.78	1.88
C	0.92	0.96	1.00
C1	0.47	0.52	0.57
C2	0.19	0.24	0.29
C3	1.15	1.20	1.25
C4	0.30	0.35	0.40
C5	1.65	1.75	1.85
C6	-	0.200	-
L	0.35	0.40	0.45
L1	1.62	1.67	1.72
L2	-	1.27	-
L3	0.319	0.369	0.419
L4	5.62	5.67	5.72
L5	0.35	0.39	0.44
L6	0.85	0.90	0.95
L7	1.62	1.665	1.72
L8	9.16	9.21	9.26
L9	9.905	10.105	10.305
L10	-	1.00	-

11.Note

- Hall chips are sensitive devices, and electrostatic protection measures should be taken during use, installation, and storage.

- During installation and use, mechanical stress applied to the device casing and leads should be minimized as much as possible.
- It is recommended that the welding temperature should not exceed 350 ℃ and the duration should not exceed 5 seconds.
- To ensure the safety and stability of Hall chips, it is not recommended to use them beyond the parameter range for a long time.

12. Historical Version

No.	Time	Describe
1	January,2024	Compile and publish
2	May,2024	Update some ambiguous text descriptions
3	July,2024	Add TO94-3L packaging